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LI.—*On the Development of Holothurians.* By Dr. HUBERT LUDWIG *.

MY sincere thanks are due to the Royal Academy of Sciences for having several years ago furnished me with the means of making a second † sojourn at the Zoological Station at Naples. For a long time I was prevented from going; and it was not until last spring that I was able to make the journey, the results of which I now have the honour to communicate.

I had proposed to myself, as the principal object of my investigations, to trace the development of a Holothurian as far as possible into the post-embryonic and post-larval life, and selected for the purpose the common Mediterranean *Cucumaria Planci*, since, from previous experiments, it appeared to be the most suitable of Mediterranean sea-slugs for prolonged culture in aquaria, and is universally regarded as a thoroughly typical Holothurian. At the same time I made further progress with my monograph on the Mediterranean Echinoderms, which I had undertaken for the 'Fauna

* Translated from the 'Mathematische und naturwissenschaftliche Mittheilungen aus den Sitzungsberichten der Königlich Preussischen Akademie der Wissenschaften zu Berlin,' Heft ii. Feb. 1891, pp. [179] 85–98 [192].

† The chief result of a former stay was the development of *Asterina gibbosa* (Zeitschr. f. wiss. Zool. Bd. 37, 1882).

und Flora des Golfes von Neapel,' and availed myself besides of the favourable opportunity for contributing to the solution of the question which has recently been raised as to the function of the madreporite of Echinoderms in general. The result of the observations which I directed towards this latter point I published some time ago in a paper entitled "Ueber die Function der Madreporenplatte und des Steinkanals der Echinodermen," which appeared in the 'Zoologischer Anzeiger,' no. 339, 1890. Another result of this last visit to Naples is the description which has just appeared * of the rediscovered Risso's *Molpadia musculus*, and to which I appended observations on the phylogeny and classification of the class Holothurioidea.

But to return to the principal object of my investigations as stated above, I may begin by remarking that I succeeded in keeping the young of *Cucumaria Planci* for a much longer time than any one had been able to do before in the case of this or any other Holothurian, as they were kept by myself from March 16 until April 17, and subsequently under the care of the excellent Conservator, Signor Lo Bianco, until July 9, therefore for a period of one hundred and sixteen days in all. On the whole, after the barrel-shaped stage is passed on the eighth and ninth day, the development thenceforward proceeds but very slowly. The larvæ and young animals are so absolutely opaque and so abundantly filled with calcareous bodies that I was forced to adopt the circumstantial method of careful decalcification and conversion into continuous series of sections, whereby I naturally had recourse to suitable methods of killing and preserving the animals. Owing to the minute size of the cells and the closeness with which the rudiments of the various organs are crowded together, none of the sections had to be thicker than 5–7·5 μ, in order to give trustworthy results. In consequence of these circumstances and the large number of figures required for a minute representation, the whole study makes considerable demands on time and patience. Publication in detail must therefore be postponed for some time. For the present I would confine myself to communicating as briefly as possible certain results which appear to me to be worthy of notice, while at the same time referring the reader to my critical treatise on the literature of the subject, which has just been published in Bronn's 'Classen und Ordnungen des Thierreiches.'

As at that time I had no reason for doubting the trust-

* "*Ankyroderma musculus* (Risso), eine Molpadiide des Mittelmeres, nebst Bemerkungen zur Phylogenie und Systematik der Holothurien," Zeitschr. f. wiss. Zool. Bd. 51, 1891, pp. 569–612.

worthiness of the statements made by Selenka as to the earliest developmental stages of *Cucumaria Planci*, I did not begin my investigations until the eighth day of the development. Subsequently, however, the conviction has forced itself upon me that my confidence went too far. The stages of the first seven days of development also must be investigated afresh, and I hope that I shall succeed in obtaining these this spring. The following observations, therefore, refer exclusively to stages which are older than seven days.

I was unable to confirm the customary view that in the Holothuria the plane of symmetry of the young Echinoderm coincides with that of the larva. On the contrary, these two planes intersect one another in the same way as I have proved them to do, *e. g.* in the development of *Asterina gibbosa*. In the anterior (oral) region of the stage which is transitional between the barrel-shaped larva and the young Echinoderm the plane of symmetry of the young animal diverges from that of the larva towards the left, but in the posterior region towards the right. The two planes of symmetry, therefore, cut one another at acute angles. In addition to this, the longitudinal axis also of the young *Cucumaria* is not identical with that of the barrel-shaped larva. In the anterior region of the body the longitudinal axis of the young *Cucumaria* diverges towards the ventral surface, in the posterior region, on the contrary, towards the dorsal surface from that of the larva. The peculiar difficulties which beset the proper orientation and the comprehension of transverse and longitudinal sections are evident at once from these conditions.

Water-vascular System.—The water-vascular ring and the radial canals have already assumed their permanent position on the eighth day. The spot at which the closure of the ring took place can no longer be distinguished. The general position of the water-vascular ring, corresponding to the relations of the plane of symmetry and the longitudinal axis as mentioned above, is such that its ventral region lies further towards the rear than its dorsal region, and at the same time its left half slightly further towards the rear than its right. It is only loosely connected with the fore-gut by means of few fine, short, suspensory fibrils. I was not able to detect muscle-fibres in the wall of the water-vascular ring at any of the stages which I examined. The five radial vessels arise from the ring with a wide lumen, without any constriction or formation of valves. The median ventral radial vessel on the eighth day already extends backwards with its blind end to a point somewhat beyond the place of origin of the first two sucker-feet canals, which arise from it and are already in existence.

On the following days it becomes more and more evident that this vessel exceeds the other four not only in length, but also in diameter. But, in addition to this, these four differ again among themselves, for the two latero-ventral canals are shorter and narrower than the two latero-dorsal ones. This difference between the five radial vessels continues far into the life of the young animal, and is only adjusted at a late period by means of subsequent processes of growth on the part of the four lateral radial vessels. Again, with regard to the formation of the musculature in the walls of the radial vessels, the median ventral canal is in advance of the remaining four, and among these, again, the two dorsal ones are in advance of the two ventral. For while the first distinct muscle-fibres appear in the wall of the median ventral radial vessel as early as the thirteenth day, it is not until the seventeenth day that the two latero-dorsal vessels acquire their first muscle-fibres, while three days more elapse before a similar event occurs for the two latero-ventral radial vessels. The whole of these muscle-fibres are limited to that section of the radial vessels which lies externally and posteriorly to the ring of pharyngeal ossicles. On the other hand, in the short portions of the radial vessels which lead to the water-vascular ring internally to the radial pharyngeal ossicles, I was still unable to detect any trace of muscle-fibres on the forty-fifth day of development. The muscle-fibres of the radial vessels are all longitudinal, are supplied from the cells of the epithelium of the hydrocœle, and occur (as in the case of the adult animal) in that wall only of the radial vessels which is turned towards the upper surface of the body, where they are arranged side by side to form a single layer.

The relations in which the young tentacles stand towards the regions of the body and the water-vascular system prove to be of especial interest. On the eighth day of development five tentacles have already been developed. Their position with regard to the mouth, and particularly with regard to the ciliated bands of the barrel-shaped larva, is different from that described by Selenka. They lie in a spacious oral atrium, into which they can be completely retracted; the atrium is then connected with the exterior by means of a circular sharp-edged opening. If, however, the tentacles are extended the oral atrium simultaneously flattens out, and the tentacles now enable it to be seen that they are all five situated in front of the second ciliated band of the larva (I regard the cilia of the cephalic hump as the first ciliated band). Selenka further states that the first five tentacles, when they are extended, are so arranged that, commencing from the front, we can distinguish a first pair, a second pair, and an unpaired tentacle. The true state of the case is exactly the opposite: in front lies an unpaired tentacle, followed by the four others, in two pairs, one behind the other. This arrangement does not become perfectly distinct until we take into consideration the fact, which has been hitherto overlooked, that the plane of symmetry of the young *Cucumaria* diverges in front towards the left and behind towards the right from the plane of symmetry of the larva. The arrangement of the tentacles which I have just indicated refers strictly only to the plane of symmetry of the young Holothurian. With reference to the plane of symmetry of the larva, on the other hand, the tentacles are asymmetrically arranged, so that three of them belong to the left half of the body of the larva and the two others to the right.

According to Kowalevsky and Selenka the water-vessels of the first five tentacles arise immediately from the water-vascular ring and alternate with the radial vessels. This statement is absolutely erroneous. *The tentacular vessels arise, on the contrary, from the growing radial vessels.* Semon's speculations upon the phylogeny of Echinoderms, in so far as they are based upon the assumption that the primary tentacles in all Holothurians arise from the water-vascular ring, and on their part determine the true radii of the Holothurian body, consequently entirely miss the mark. In the case of *Cucumaria* their correctness is entirely overthrown by the fact that the first five tentacular vessels are by no means disposed in regular radial fashion. Were this the case a tentacular vessel would be given off from each of the five radial vessels. This, however, is not the fact. The arrangement of the first five tentacular vessels is neither radial nor bilaterally symmetrical, but *asymmetrical, in that the two tentacles of the two ventral interradii receive their water-vessels from the median ventral radial vessel, while the tentacle of the median dorsal, as well as that of the left dorsal interradius, is supplied from the left dorsal radial vessel, and lastly the tentacle of the right dorsal interradius from the right dorsal radial vessel.* The median ventral and the left dorsal radial vessels therefore each give off two tentacular vessels, but the right dorsal radial vessel only one. The points of origin of the two tentacular vessels of the median ventral radial canal are situated exactly opposite one another; so are also the two tentacular vessels of the left dorsal radial canal. The two latero-ventral radial vessels, on the other hand, give off for the present, so long as only five tentacles altogether are present, no tentacular canals at all, and therefore in this respect are behind the three other radial vessels. Regarded from outside, it is the anterior unpaired tentacle of the eighth day of development and its neighbour on the left, which belong to the left dorsal radial canal; the tentacular vessel on the right of the unpaired one belongs to the right dorsal radial canal; the two tentacles of the posterior pair, however, are those which are furnished from the median ventral radial canal.

The relation of the primary tentacles to the radial vessels, which has just been described, is perfectly constant. It was possible to demonstrate it without meeting with a single exception for all the numerous young *Cucumariæ* of the most widely different ages, from the eighth to the hundred and fifteenth day, in uninterrupted series of transverse and longitudinal sections, and may therefore be regarded as a rule, though certainly a very peculiar one.

It was not until the hundred and sixteenth day that among a portion of the young animals an increase of tentacles took place, and seven altogether were found to be present. The sixth and seventh tentacles are situated exactly opposite one another with reference to the median plane of the Holothurian, and receive their water-canals from those two radial vessels, which hitherto had taken no part whatever in the giving off of tentacular vessels, namely from the right and left ventral radial vessels. The two radial vessels each send off the new tentacular vessel in a dorsal direction, therefore into the left and right dorsal interradii. Previous to this only a single tentacle existed in each interradial region surrounding the mouth. Now, however, after the formation of the sixth and seventh tentacles, each of the two latero-dorsal interradii possesses two, while the median dorsal and the two ventral interradii now as before each accommodate only one. The seven tentacles are accordingly disposed upon the five interradii in precisely the same way as that which I determined years ago in the seven-tentacled young of the viviparous *Chiridota rotifera*. Since in the adult ten-tentacled *Cucumaria* each radial vessel gives off two tentacular canals, we may conjecture, as regards the further multiplication of the tentacles, that the eighth arises on the left (dorsal) side of the right dorsal radial vessel, the ninth and tenth, however, on the ventral side of the left and right ventral radial vessels, whereby an exactly radial distribution of the ten tentacles of the adult animal is finally attained. In connexion with the successive development of the tentacles which has thus been traced, it may also be worth while mentioning the fact that the two ventral tentacles, although in the adult animal they are considerably smaller than the remaining eight, belong not to the five secondary tentacles, but to the five primary ones.

The whole of the tentacular canals arise from the radial vessels by a basal portion, which is at first very short and narrow, but afterwards increases in length, and which opens by means of a valve into the wider section of the tentacular canal, lying in the tentacle itself. These valves, in spite of their small size, are constructed of two semilunar folds, precisely as is already known to be the case in the tentacles of *Synapta*. The narrow basal portions of the tentacular canals, as well as the valves at the distal end of these portions, lie internally to the radial ossicles of the pharyngeal ring, which are already present on the eighth day of development. Beyond the valve the expanded section of the tentacular vessel bulges out backwards, forming a short cæcal process which lies outside the young calcareous ring, and there rests upon the lateral branches of two neighbouring radial ossicles. This cæcum is the rudiment of the homologue of a tentacular ampulla, which Hérouard has shown to exist in the adult animal. No muscle-fibres could be distinguished in the wall of the narrow portion of the tentacular vessel, even in the most advanced of the developmental stages examined. In the expanded portion, on the other hand, distinct *longitudinal muscle-fibres* (and only such), furnished by the cells of the epithelium of the hydrocœle, appear in a single layer as early as the tenth day. Until the fifteenth day the tentacles are simple cylindrical structures with rounded tips, which are beset by the tiny hyaline papillæ already noticed by Krohn and Selenka. On the day named the subsequent *arborescent shape* of the tentacles begins to be ushered in, by the bifurcation of the tips. On the following days these two branches are soon succeeded by other branches which appear below the tip. The whole of the branches enclose from the beginning a cæcal process of the tentacular vessel.

Rudiments of the *first two feet* are already present on the eighth day. At first they each lie concealed in a pit-shaped hollow of the integument, and on emerging from this pit, which then flattens out, have the form of a small hemispherical protuberance. During the following days they elongate more and more into cylindrical tubes, and on the eighteenth day a well-developed terminal disk can already be distinguished. The two primary feet receive their water-vessels, as has already been observed by Selenka, from the terminal portion of the median ventral radial vessel, from which they arise exactly opposite one another. Nevertheless, by closely observing them from the eighth to the eighteenth day, we notice that the right foot projects from the surface of the body a little in advance of the left, which again is traceable to the fact that the plane of symmetry of the Holothurian assumes the oblique position with regard to the plane of symmetry of the larva which has already been mentioned. The *musculature* of the young feet arises in immediate prolongation of the musculature of the radial vessel, exclusively in the shape of longitudinal muscle-fibres, on the outer surface of the pedal vessel, and originates, precisely like the muscles of the radial vessels and the tentacles, from the cells of the epithelium of the hydrocœle. As early as the tenth day (therefore even before the appearance of the muscle-fibres in the corresponding radial vessel) the longitudinal muscle-fibres form a fine unilamellar sheath, which is still absent in that section of the pedal canal only, which very much later bulges out to form the pedal ampulla. At the point of origin of the pedal vessel from the median ventral radial vessel a valvular arrangement is indeed present, but much more feebly developed than the similar valves of the tentacular canals.

A *third foot* does not make its appearance until the forty-fifth day. It arises in front of the two primary feet, always lies to the left of the median plane, and, like the others, receives its water-canal from the median ventral radial vessel, which consequently now supplies two left feet and a right one. In the meantime, from the proximal portion of the first two pedal canals, there have arisen ampulliform expansions into the body-cavity.

On the eighty-fourth day a *fourth foot* has come into existence, which likewise derives its water-canal from the median ventral radial vessel. It lies still further towards the front than the third, nevertheless not to the left but to the right.

A further increase in the number of feet does not take place until the hundred and eleventh day. The *fifth foot*, however, which then appears, no longer belongs, like its forerunners, to the median ventral radial vessel, nor even to the ventral surface at all, but arises on the left (= ventral) side of the left dorsal radial vessel, and, moreover, in the region of the anterior half of the body. The same two radial vessels, therefore, are now taking part in the formation of feet, which also in the formation of tentacles in so far preceded the rest of the radial vessels that they were the first to furnish their definite number of two tentacles each.

The *Polian vesicle* lies, contrary to the position attributed to it by Selenka in his figure, not in the right half of the body, but without exception in the left, and, indeed, invariably in the left dorsal interradius, and consequently in the absolutely constant position in which Hérouard also met with it in the adult. No valvular arrangement whatever is present at its wide-mouthed opening into the water-vascular ring. From the fifteenth day onwards circular muscle-fibres may be recognized in its wall: they are arranged concentrically in a single layer round a point corresponding to the blind end of the vesicle. The muscular layer ceases at the opening of the vesicle into the water-vascular ring. In its origin it also is derived from the hydrocœle-cells, which represent the inner epithelium of the entire water-vascular system.

The young *stone-canal* possesses a vesicle-shaped expansion, overlooked by Selenka, the epithelial coat of which preserves the same constitution as in the rest of the stone-canal only in the inner half of the vesicle (*i. e.* the one which is turned towards the interior of the body), while in the outer half (*i. e.* that lying nearer the surface of the body) it is greatly flattened. This expansion is the earliest rudiment of the subsequent madreporic head of the perfect stone-canal, and may therefore be designated as the "*madreporic vesicle.*" Hitherto it has only been casually noticed by Bury, and termed by him the "anterior enterocœle." On the part of the mesenchyma it is surrounded by an incomplete calcareous *lattice-work envelope*, which has long been observed in other Holothurians. The valve which was supposed by Hérouard to exist in the adult *Cucumaria* at the exit of the stone-canal from the water-vascular ring is not present; the columnar epithelium of the stone-canal passes at this point almost suddenly into the pavement-epithelium of the water-vascular ring. The outer end of the primary stone-canal, leading from the madreporic vesicle to the dorsal pore, lies, as does the dorsal pore itself, which is subsequently obliterated, about the eighteenth to twenty-fourth day, not in the median plane of the Holothurian as determined by the dorsal mesentery, but to the right of it, which is once more explained by the oblique position of this median plane with reference to that of the larva, to which frequent allusion has already been made. In the same way it is perhaps possible to explain the preference which the stone-canal of adult Holothurians, especially in the Aspidochirotæ, exhibits for the right half of the body. In young animals of the ninety-eighth day the madreporic vesicle has opened into the body-cavity on its thin-walled side, thereby effecting the permanent connexion between the stone-canal and the body-cavity.

Nervous System.—On the eighth day of development rudiments of the central portions of the nervous system, the circumoral ring, and the radial nerves already exist. Both the nerve-ring as well as the radial nerves emanating from it at this stage consist solely of closely-packed cells, arranged in several layers one above the other. It is not until the following day that beneath the cells of the nerve-ring a very finely fibrillar layer is visible, the fibres of which run parallel with the longitudinal axis of the nerve-ring. From the thirteenth day onwards we observe isolated cells scattered about at random between these fibres. With this the structure of the nerve-ring has reached a point at which it remains in all subsequent stages of development examined by me. It therefore consists of a superficial layer of cells (*i. e.* a layer turned towards the exterior), and beneath this a layer of fibres sheltering scattered cells. The five radial nerves resemble the five radial vessels of the water-vascular system which they accompany in so far as they differ from one another in thickness and length and also develop unequally fast from a histological point of view. As among the radial vessels, so also in the radial nerves the median ventral one is in advance of the others, and among the latter, again, the two dorsal take precedence over the two ventral ones. Even on the eighth day the rudiment of the median ventral nerve extends to beyond the rudiment of the first two feet, and here reaches somewhat further backwards than the blind end of the median ventral radial vessel. The histology of the median ventral radial nerve is similar to that of the nerve-ring, since on the eighth day the nerve consists solely of cells, but on the ninth of a layer of cells, which is merely superficial, and of a subjacent layer of fine longitudinal fibres. The separation of this fibrous layer commences in the proximal portion of the nerve, and from here gradually progresses until it reaches the distal portion, though the extreme end of the nerve always retains a purely cellular character in the stages which I examined. In one respect only is the nerve-ring temporarily in advance of the median ventral radial nerve, namely with regard to the appearance of cells in the interior of the fibrous layer. At the time when we meet with cells in the fibrous layer of the nerve-ring (*i. e.* the thirteenth day) they are as yet entirely wanting in that of the radial nerve. On the twelfth day the separation into outer cellular and inner fibrous layer can be seen in the two latero-dorsal nerves also, while the same separation in the case of the two latero-ventral nerves is not visible until the eighteenth day. Primarily the cellular stratum of the radial nerves is two to three layers thick; subsequently, however, it is only one layer thick, and it then represents the well-known external marginal cells of the adult.

On the ninth day the nerve-ring gives off five tentacular nerves, which are interradial in origin and lie upon the muscular layer of the tentacular vessels, on the side which is towards the mouth. On the seventeenth day a nerve-branch may be observed passing off from each side of the posterior region of the median ventral radial nerve to the primary foot.

As early as the eighth day of development the nervous system of the young animal has no longer any connexion whatever with the ectoderm of the surface of the body or of the oral atrium; it is everywhere separated from the ectoderm by an intervening layer of mesenchyma. Nevertheless the outer surface of the nerve-ring and of the radial nerves does not come into immediate contact with this mesenchyma, but is separated therefrom by a cleft which persists throughout the whole of the subsequent life as an "epineural ring" in the case of the nerve-ring and as an "epineural canal" in the case of the radial nerves. The epineural ring and epineural canals are in free communication with one another from the beginning; the latter are merely processes of the former. On the other hand, a connexion between the epineural cavities and any other cavity of the body could not be determined. It follows from these observations that Hérouard is perfectly right in regarding the epineural ring and epineural canals of the adult animal as normal structures. The tentacular and pedal nerves are also accompanied by epineural spaces; those of the tentacular nerves branch off from the epineural ring, those of the pedal nerves from the corresponding radial epineural canal.

Until the twentieth day the young radial nerves lie immediately upon the outer walls of the radial vessels. It is not until this day that—and at first, too, only in the median ventral radius—a very fine cleft gradually appears between the inner side of the radial nerve and the outer side of the radial vessel. In all probability this cleft is the rudiment of the subsequent radial "pseudo-hæmal canal." As soon as this cleft is formed, cells which are derived from the lateral margins of the radial nerve pass to the outer wall of the cleft, here to become the inner marginal cells of the perfect radial nerve.

On the other hand, I was unable to recognize, even in the latest of the stages examined, either the perpendicular fibres, or the transverse septum, or a trace of the two cellular columns formed by the outer marginal cells, and therefore think I am entitled to suppose that all these arrangements which are known to exist in the radial nerves of the adult animal are to be regarded as secondary acquisitions.

Auditory organs, which from general considerations I hoped to find, I sought for entirely in vain. In no shape, and at no stage of development, either upon the nerve-ring or the radial nerves, was I able to detect anything of the kind.

The musculature of the body-wall is furnished from the cells of the parietal enterocœle. First to be formed is the median ventral longitudinal muscle, which, on the ninth day, can already be distinguished as a fine single layer of longitudinal fibres on the inner side of the median ventral radial vessel. On the thirteenth day the rudiment of this muscle has already become somewhat broader than the transverse diameter of the radial vessel. The separate fibres of which the muscle consists lie closer together than the muscle-fibres in the outer wall of the radial vessel, from which they are subsequently still further distinguished by their more than double thickness. In front the young longitudinal muscle commences (as in the case of the adult animal) on the outer side of the corresponding radial ossicle of the pharyngeal ring; posteriorly it extends as far as the region of the origin of the first two pedal vessels.

Not until after the median ventral longitudinal muscle has been formed do we observe, on the fifteenth day, isolated transverse muscle-fibres on the outer surface of the parietal enterocœle, and on the eighteenth day a transverse muscular layer of the body-wall, interrupted in the radii, is distinctly visible. At the anus the transverse muscle-fibres draw closer together and form round it a sphincter-muscle (forty-fifth day).

The four longitudinal muscles of the lateral radii in the order of their appearance and in their original inequality of strength follow the relations of the radial vessels and the radial nerves, since in their case also the two latero-dorsal precede the two latero-ventral ones both in point of time and in actual length. The former are visible on the seventeenth day, the latter not until the forty-fifth.

The splitting-off of the retractile muscles from the longitudinal ones appears to take place very late, since I was only able to detect the first traces of it in a few individuals of the hundred and eleventh day.

The calcareous bodies of the integument are already visible in the stage of the barrel-shaped larva, and are taken over *en masse* by the young *Cucumaria*, so that a true larval skeleton, peculiar to the larva, does not exist. Each calcareous body originally has the form of a tiny rod, which, by repeated bifurcations of its ends, which always take place at an angle of 120°, and subsequently by the contact and fusion of its branches, develops into a small lattice-work plate. In the course of this process it may be seen that a thickening of the rods simultaneously takes place by apposition. Hérouard's view, according to which only a single formative cell corresponds to each mesh of the latticed plate, is not supported by my observations; on the contrary, I observed as distinctly as possible that usually several, *i. e.* two to six, formative cells occur in each mesh. The five foremost latticed plates are so arranged that their longitudinal axes fall exactly in the direction of the radii. These five plates together form a pentagonal projecting sheath for the crown of tentacles. Each tentacle corresponds in position to the line of contact of two plates. Further backwards these five oral latticed plates (=pseud-oral plates) are connected with others of similar formation, which originally come into contact with each other just as little as do the oral plates at their first appearance. Soon, however, they become larger and more numerous, collect close together, and then thrust their edges over one another like the slates of a roof, so that the fore border of one plate rests upon the hind border of the one next in front. In the walls of the tentacles and feet, also, smaller latticed plates very soon appear in large numbers. About the hundredth day a second sort of calcareous body is seen to appear in the integument of the trunk, occupying a position nearer the surface than the latticed plates which have hitherto alone been present. It is distinguished by its remarkable smallness, elegance, and richly-branched shape, and in form it is arched in such a way that its concave side is turned outwards, its convex side inwards. Further particulars as to the form, origin, and arrangement of the calcareous bodies and their relation to the calcareous bodies of the adult will be communicated by means of figures in my detailed memoir. There, also, it will be proved that the calcareous ring is formed from the body-wall, and shows remarkable relations between its radial ossicles and the ambulacral ossicles of the skeleton of the starfish.

Integument and Mesenchyma.—The circumstance appears to me to be not without interest that after the complete disappearance of the ciliated bands of the larva it is not possible to make a sharp distinction either between the ectoderm and the gelatinous nucleus of the cephalic hump (so long as this is still present in the neck of the young *Cucumaria*), or between the ectoderm and the mesenchyma of the wall of the trunk. Ectoderm and mesenchyma in young Cucumarians form a single tissue, which does not differentiate until later into a distinct epithelium and a subjacent layer of connective tissue.

Blood-vascular System.—The supposition that the blood-vascular system, as I was the first to demonstrate in the case of a starfish, would be traceable to remnants of the segmentation-cavity, or at any rate to clefts in the mesenchyma, has fully justified itself. Between the visceral layer of the enterocœle and the endodermic wall of the mid-gut there appears on the thirteenth day a distinct space, which partly bulges out to form the marginal vessels of the perfect intestine and partly develops into the blood-spaces which are found in the thickness of the wall of the mature intestine. On the seventeenth and eighteenth days we can already observe the development of a mesenterial and an antimesenterial marginal vessel upon the mid-gut, to which during the following days a simple transverse vessel is added.

Just as between the visceral layer of the enterocœle and the endoderm of the mid-gut, so also, in a similar way, lacunar vessels are developed between the parietal layer of the enterocœle and the mesenchyma of the body-wall. Since a firm and intimate fusion of the parietal enterocœle with the body-wall takes place in the region of the radii only, in the intermediate spaces, that is in the interradii, a gap remains between the enterocœle and the body-wall, which may be detected even in quite young stages, and is identical with the large lacuna of the body-wall described by Hérouard in the adult animal.

Digestive Organs.—The oral atrium already alluded to is clothed by a very flat unilamellar epithelium, which is directly continuous with the external covering of the tentacles. At the bottom of the oral atrium lies the opening of the mouth, which on the eighth and ninth day is extraordinarily narrow and takes in no food as yet. The folding of the intestine, subsequently so strongly marked, is already indicated on the ninth day, and from the beginning follows the same regular direction as in the adult animal. The fore-gut narrows posteriorly, and on the twelfth day is already attached by means of fine radial strands of connective tissue to the inner side of the young calcareous ring. Not less distinct and much more numerous are at the same period the suspensory cords which attach the hind-gut to the body-wall. On the fifteenth day the mid-gut has widened considerably; the fore-gut is now marked off from it by a sharp constriction. On the seventeenth day I was able to observe food (Diatoms) in the mid-gut, derived from without, although at this time the food-supply stored up in the gelatinous nucleus of the cephalic hump is not yet exhausted. Mouth and fore-gut also have now become more spacious than before, and the mucous membrane of the latter exhibits distinct longitudinal folds. Moreover, the fore-gut by this time (eighteenth day) possesses a layer of distinct circular muscle-fibres, which appear to me to be in no way derived from cells of the mesenchyma, but from the enterocœle-cells which lie closely upon the fore-gut. From the mid-gut an anterior portion is constricted off, which becomes the stomach of the adult, but as yet possesses muscular fibres in its wall just as little as does the remainder of the mid-gut. In the later stages also which were examined by me I failed to trace muscle-fibres in stomach and mid-gut, while in the end-gut from the forty-fifth day onwards longitudinal muscle-fibres were distinctly recognizable.

LII.—*Natural History Notes from H.M. Indian Marine Survey Steamer 'Investigator,' Commander R. F. Hoskyn, R.N., commanding.*—Series II., No. 1. *On the Results of Deep-sea Dredging during the Season* 1890–91. By J. Wood-Mason, Superintendent of the Indian Museum, and Professor of Comparative Anatomy in the Medical College of Bengal, and A. Alcock, M.B., Surgeon I.M.S., Surgeon-Naturalist to the Survey.

[Continued from p. 362.]

[Plate XVII.]

Phylum **ECHINODERMA.**

Class ASTEROIDEA.

The Asteroidea form a good collection, which we have arranged under twenty-three species, sixteen genera, and eight families. Of these twenty-three forms nine appear to correspond with species described in the 'Challenger' Report, while fourteen seem to be new to science.

Except as regards life-coloration and distribution we have not been able to learn anything very new concerning the Asteroidea of the deep sea. Most of them appear to live, like their shallow-water relatives, upon Mollusca. In the stomachs of some of our specimens the carapaces of Crustacea have been found. The Porcellanasteridæ, so far as our rather limited